JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. VIII FEBRUARY 19, 1918 No. 4

PHYSICS.—*An optical ammeter.* PAUL D. FOOTE, Bureau of Standards.

The high precision in the measurement of temperature possible by use of a properly designed Holborn-Kurlbaum optical pyrometer equipped with a suitable pyrometer lamp is well recognized. If the lamps are operated below 1300° to 1500°C. the calibration of the pyrometer will not change appreciably after years of ordinary use. These two factors, accuracy of photometric settings and constancy in calibration of the lamps, permit the adaptation of this method of photometry to the measurement of current. In the present note two forms of current measuring instrument are described, one of which is strictly a hot-wire ammeter with the hot wire at a temperature between 600° and 1500°C., and the other a device for adjusting a current, by optical methods alone, to any preassigned value. The first method should prove especially useful for the accurate measurement of alternating current of high frequency.

In order to show what precision may be expected in measurement of current through the pyrometer lamp when the instrument is sighted on a source of constant brightness we will make the assumption that a photometric match of the tip of the lamp filament against the uniform background can be made with an accuracy of 0.5 per cent. This assumption is reasonable for precision photometry of this type, but even if the accuracy were only 5 per cent surprisingly accurate measurement of current can be obtained, as will appear below. The current temperature relation for a particular lamp used, G. E. No. 8, has the

following form where i is the current in amperes and the absolute temperature of the filament:

(1) $i = 0{,}09258 - 0.000010719\ (\vartheta - 273) + 0.00000018074\ (\vartheta - 273)^2$

whence

$$(2) \qquad \frac{\delta i}{i} = \frac{[-0.000010719 + 0.0000003615\ (\vartheta - 273)^2]\ \vartheta}{i}\ \frac{\delta \vartheta}{\vartheta}$$

The brightness-temperature relation for this lamp is obtained from Wien's law as follows:

$$(3) \qquad \frac{\delta J}{J} = \frac{c_2}{\lambda \vartheta}\ \frac{\delta \vartheta}{\vartheta}$$

where $c_2 = 14350$, and J = intensity corresponding to λ the wave length of the monochromatic light employed. In optical pyrometry this wave length is usually made about $\lambda = 0.65\mu$ by the use of a suitable red glass. Combining equations (2) and (3) one obtains:

$$(4) \qquad \frac{\delta i}{i} = \frac{[-0.000010719 + 0.0000003615\ (\vartheta - 273)^2]\ \vartheta^2}{i}\ \frac{\lambda}{c_2}\ \frac{\delta J}{J}$$

Thus for a particular value of such as 1273° absolute we have:

$$(5) \qquad \frac{\delta i}{i} = 0.06\ \frac{\delta J}{J}$$

Hence, if the photometric match is made with an accuracy of 0.5 per cent *the current i is determined with an accuracy of 0.03 per cent, or to three parts in ten thousand.* If the photometric match is made with an accuracy of only 5 per cent, the current is determined to three parts in one thousand, which is a precision scarcely to be obtained by an ammeter, especially for alternating current.

One means for adapting this method of photometry to the measurement of current is shown in figure 1, where A' is a red glass screen, A the pupil diaphragm, B the ocular lens, C the electric lamp connected to the electrical apparatus, F a second electric lamp, E a diffusing opal glass screen and D a lens focusing upon E and C. The alternating current flowing through C

brings the lamp to incandescence. By adjusting the rheostat G the brightness of the lamp C is matched against the image of the background E illuminated by F. The current required for the match is read potentiometrically by use of the resistance standard K. Hence the value of the alternating current is determined by an auxiliary measurement of direct current. The relation between the currents through F and C is obtained in the primary standardization of the instrument by using a direct current through C and measuring this potentiometrically. For the highest precision a commutating switch may be used with C,

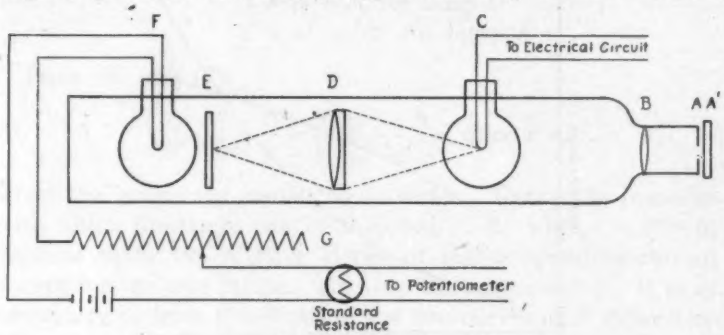

Fig. 1. An optical ammeter.

so that the standardization with direct current may be performed immediately following the observations with alternating current. The range of currents which can be measured by any one system of lamps exceeds 1:2, and lamps having filaments of varying sizes may be used for a large range in value of currents. Thus one lamp may be employed for alternating currents between 0.25 and 0.50 ampere, another lamp between 0.5 and 1 ampere, etc. Or with the same lamp, the range may be extended by the use of shunts, although this latter method is probably objectionable for very high frequency. If the induction effect becomes serious for the horseshoe filament, a lamp having a straight wire filament can be used.

When a suitable magnification system is employed, the diffusing screen E is unnecessary and a magnified image of F may be

projected directly on the filament C. Another modification of the above method is obtained by reversing the positions of the lamps F and C. The above described principle can be employed for the measurement of alternating voltage, as well as current. In this case the lamp filament must be of very small wire in order that the instrument possess a high resistance. For voltages from 60 to 110 volts a 7.5-watt lamp, which has a resistance of 1600 ohms, should prove satisfactory.

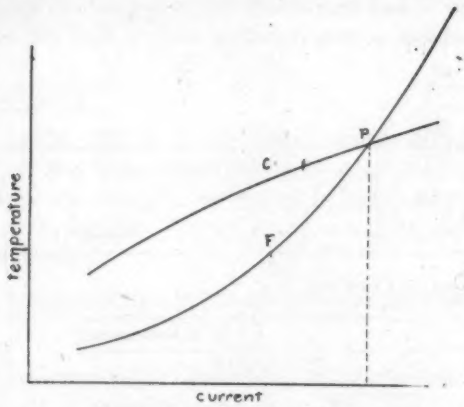

Fig. 2. Current-temperature relation for two lamps C and F. If a diffusing screen is used in front of the lamp F, the above curve F refers to the apparent temperature of the screen.

The apparatus shown in figure 1 may be employed for the determining of a fixed current of any preassigned value. A system similar in principle to this has been used, for determining a fixed temperature but to the writer's knowledge the method has never been employed for current measurements. Suppose that the apparent temperature-current relations of the lamps C and F are represented by the curves shown in figure 2. The two curves intersect at the point P. Hence, when the lamps C and F are connected in series and are caused to glow by either alternating or direct current the two filaments possess the same

[1] Siemens and Halske French Patent No. 466064.

temperature and are accordingly matched for the current corresponding to P. The condition for a match thus defines a standard current which can be adjusted to any desired value by the use of a suitable shunt. The match is effected by use of an adjustable rheostat in series with the two lamps. The precision obtainable is much less than that possible with the first method described and depends upon the slopes of the two curves of figure 2 at the point of intersection. Near the point P these curves can be assumed to be straight lines. Whence we have:

(6) $$i = a + bt \text{ for lamp } C$$

(7) $$i' = a' + b't' \text{ for lamp } F$$

From (6) and (7)

(8) $$\delta(t-t') = \frac{\delta i}{b} - \frac{\delta i'}{b'} = \frac{b'-b}{bb'}\delta i, \text{ since } i' = i$$

when the lamps are connected in series. Hence the precision with which the lamps can be matched (i. e., when $t - t' = 0$) depends upon the relative slopes of the temperature-current curves for the two lamps. As seen from equation (8) it is of advantage to have the slopes of the two curves at P differ considerably. There would be no accuracy whatever if the slopes were nearly the same. Using apparatus assembled as shown in figure 1, but without paying special attention to the procuring of lamps having widely different constants, b, the readings given in table 1 were made by four different observers, one of whom was unskilled in photometric matching. The accuracy is only fairly satisfactory, but undoubtedly could be improved by the proper selection of lamps.

TABLE 1

C. W. K.	E. F. M.	C. O. F.	P. D. F.
0.933	0.930	0.933	0.934
0.934	0.923	0.931	0.934
0.935	0.929	0.933	0.933
0.933	0.930	0.933	0.933
0.933	0.930	0.933	0.933
0.932	0.932	0.931	0.933
Means 0.9333	0.929	0.9323	0.9333

The final mean is 0.9320 ampere, and the average deviation is 0.18 per cent. The final mean, neglecting the readings of one observer, is 0.9330 ampere, and the average deviation is 0.06 per cent. Thus this method can be used to define a standard current with an accuracy of 0.2 per cent.

It may be pointed out that both of the above methods give results that are practically independent of the temperature of the room. Hence, an ammeter designed on these principles has a zero temperature coefficient.

MINERALOGY.—*Vivianite from the land pebble phosphate deposits of Florida.* THOMAS L. WATSON and STAPLETON D. GOOCH, University of Virginia.

INTRODUCTION

During recent mining operations by the Coronet Phosphate Company on its property on the Northwest Quarter of Section 34, Township 29, Range 22, about 1½ miles southeast of Plant City, Florida, fairly abundant crystals of vivianite were exposed over an area of moderate dimensions. The occurrence was noted by the junior writer, who is chemist to the Coronet Phosphate Company, and who kindly sent the senior writer a liberal supply of the mineral and matrix for study.

Although not a common mineral, vivianite has been observed both in this country and abroad in a variety of associations, more especially in veins with the sulphides pyrite and pyrrhotite, in bog iron ore deposits, and in clays and marls. In all its occurrences the mineral is regarded as secondary in origin.

Previous to the recent mining operations by the Coronet Phosphate Company near Plant City that resulted in exposing vivianite, the only reference to the occurrence of the mineral in Florida phosphate deposits found in the literature accessible to us is a general statement by Matson,[1] who remarks that vivianite has been noted at several places but is probably rare. In a

[1] MATSON, G. C. *The phosphate deposits of Florida.* U. S. Geol. Survey Bull. 604, p. 85. 1915.

recent letter to one of us (Watson), Dr. E. H. Sellards, State Geologist of Florida, states that a specimen of vivianite was brought to his office in August, 1916, by a citizen of Avon Park, Desoto County, Florida. The exact locality was not given, but Dr. Sellards says the mineral presumably came from south of Avon Park, which would place the locality some distance to the southeast of the land pebble phosphate area as defined on the map by Matson.[2] The vivianite was associated with bog iron ore.

Vivianite is apparently a rare mineral in the Florida phosphate deposits, and so far as we are aware it has not hitherto been described, although noted in places in association with phosphate deposits of the Florida type. Because of these facts and the general character of the vivianite crystals found near Plant City, the occurrence is regarded of sufficient interest and importance to warrant a published record.

GEOLOGIC SECTION

The vivianite occurs in a ferruginous or dark-yellow ocherous matrix of earthy character about 20 feet below the surface at the contact of the pebble phosphate bed with the "bedrock" (clay in this section), and partly in each. The vivianite matrix covers an area of approximately 1000 square feet, with the vivianite-bearing portion limited to about 20 feet square and 2 or 3 feet deep.

The section follows.

	Thickness in feet
Overburden:	
Black sandy soil containing organic matter	2
Sand with very little admixed clay, partly indurated and colored red by iron oxide	12
Clay, more or less phosphatic	1
Phosphate:	
Pebble phosphate with some sand	4–6
Bedrock:	
Dark yellow ocherous earth, locally hardened and red in color, containing besides vivianite scattered pebbles of phosphate and small rounded quartz grains	2+

[2] MATSON, G. C. Op. cit. Folded map in pocket.

The contact between the overburden and the phosphate bed is sharply defined. The land pebble phosphate belongs to the Bone Valley gravel formation, which is generally regarded as Pliocene in age, although Matson[3] thinks there is some evidence of the Miocene age of the phosphate. The formation is believed to be of marine origin,[4] the materials of which were probably deposited under shallow water conditions.

DESCRIPTION OF THE VIVIANITE

The mineral is distributed irregularly through the ocherous matrix as single crystals and crystal aggregates. Individual crystals attain a maximum length of 22 mm., are prismatic in form, usually much elongated, and not infrequently flattened parallel to 100, with vertical striations sometimes developed. End faces were not observed, the crystals terminating usually in rough and uneven surfaces. In the crystal aggregates, the unattached end of the individuals sometimes exhibits acicular form. Fibrous structure, usually radiate or divergent, is sometimes developed.

Perfect cleavage is developed parallel to 010. The luster is pearly on cleavage faces, vitreous on other faces. Hardness 2; specific gravity 2.693. Color varies from light or pale green through blue-green to deep indigo blue, the pale green being predominant. Streak colorless to faint bluish white, which rapidly changes to deep blue on exposure. The finely ground powder after exposure to sunlight for more than 30 days remained deep blue without any indication of changing to brown as reported by some writers. Crystals vary from transparent to translucent, becoming more or less opaque on prolonged exposure.

The optical properties of the pale-green fragments of the vivianite similar to those yielding the analysis in table 1, kindly determined for the writers by Mr. E. S. Larsen, gave the following results: Optically (+); $2V$ large; dispersion not strong; X is normal to 010; Z makes an angle of $28° 30' \pm 1°$ with c.

[3] MATSON, G. C. Op. cit., p. 69.

[4] At Pembroke aggregates of *silicified oyster shells* have been observed by Dr. Sellards and the junior writer (Gooch) in the pebble phosphate deposit.

The refractive indices are:

$$\alpha = 1.580 \pm 0.003, \quad \beta = 1.598 \pm 0.003, \quad \gamma = 1.627 \pm 0.003.$$

The grains are colorless and nonpleochroic under the microscope. On fine grinding the powder changes to deep blue, which has similar properties as the pale-green fragments, but is strongly pleochroic, with X = deep cobalt blue, Y and Z, colorless. Fragments of the deeply colored blue crystals show similar properties and absorption formula as the deep-blue powder of the pale-green fragments.

A carefully selected sample of transparent pale-green crystals of the vivianite was analyzed with the results shown in table 1.

TABLE 1

CHEMICAL ANALYSIS OF VIVIANITE (BY S. D. GOOCH)

FeO	32.64
Fe_2O_3	9.43
P_2O_5	29.99
H_2O − 105°C	11.86
H_2O + 105°C	15.84
SiO_2	0.12
CaO	0.02
MnO	0.25
TiO_2	trace
	100.15
Specific Gravity	2.693

Careful chemical tests showed the absence of Al_2O_3, MgO, the alkalies (Na_2O and K_2O), F, SO_3, and CO_2. Attention is directed in the analysis to the seemingly high percentage of ferric oxide. This constituent is invariably present in blue vivianite in varying quantity, analyses showing it to range up to 33+ per cent. The presence of ferric oxide in the colored varieties of the mineral has been regarded as due to alteration (oxidation), but microscopic examination of the mineral and the very rapid change in color of the streak or powder, suggested that the change might possibly be due to inversion from one form to another.

Microscopic examination of the Florida vivianite indicated that the blue color was not uniform but was developed in or along streaks, apparently fractures or cleavage planes or both. The

very rapid change in color of the streak of vivianite or of its powder on fine grinding, from white or faint bluish white to deep or indigo blue, is a well known property of the mineral.

Further chemical study of the mineral was undertaken to determine, if possible, whether the change in color was due to oxidation or to inversion. For this purpose a lot of uniformly colored pale-green crystals was selected and divided into two portions. The first portion was accurately weighed, dissolved *without* grinding, and ferrous iron determined. The second portion was reduced to powder by fine grinding and exposed to sunlight for five hours, after which a weighed sample of the exposed powder was dissolved and the ferrous iron determined. The results follow:

	UNGROUND VIVIANITE	FINELY GROUND VIVIANITE
	per cent	*per cent*
FeO	42.88	38.43

These figures clearly show that fine grinding of the mineral resulted in the oxidation of 4.45 per cent FeO to Fe_2O_3, equivalent to 4.94 per cent Fe_2O_3. A second lot of pale-green crystals of the Florida vivianite was submitted to Prof. F. P. Dunnington, of the University of Virginia, who found on analysis 40.58 per cent FeO and *no* Fe_2O_3 on dissolving the crystals without grinding.

The results show beyond reasonable doubt that the presence of Fe_2O_3 in blue vivianite, which is probably the common variety of the mineral, is due to oxidation and not to inversion. The rapidity with which oxidation takes place on fine grinding, manifested in very rapid change of color (blue), is noteworthy and of special interest.

COMPOSITION OF THE MATRIX

The matrix is a dark brownish yellow ocherous earth, locally hardened and red in color, containing besides vivianite irregularly scattered phosphate pebbles of chalky white color with surfaces partly smooth but usually more or less pitted, and scant rounded grains of pellucid quartz. It readily dissolves in hot dilute hydrochloric acid.

The composition of the matrix is shown in the analysis given in table 2. The sample analyzed was representative of the matrix, except that care was taken in selecting the sample to avoid as far as possible the inclusion of phosphate pebbles.

TABLE 2

CHEMICAL ANALYSIS OF VIVIANITE MATRIX (BY S. D. GOOCH)

SiO_2	4.17
Al_2O_3	4.96
Fe_2O_3	65.20
FeO	1.41
MgO	trace
CaO	1.68
Na_2O, K_2O	0.16
$H_2O - 105°C$	4.14
$H_2O + 105°C$	12.72
MnO	0.56
TiO_2	0.14
P_2O_5	5.02
F	trace
SO_3	none
CO_2	none
	100.16

The analysis clearly indicates that the matrix is not a clay, but an earth composed of the hydrates of iron and aluminum, chiefly the former, hydrous phosphates of calcium, iron, and aluminum, and some free quartz. It is characterized by the essential absence of hydrous silicate minerals, especially kaolinite, a fact confirmed by microscopic study. The slight insoluble residue left on boiling a portion of the matrix in dilute hydrochloric acid was found to be composed of quartz and not of silicate minerals.

RELATIONS OF VIVIANITE TO THE ASSOCIATED MINERALS

The principal associated minerals are hydrous oxide of iron, probably limonite chiefly, calcium phosphate forming the phosphate pebbles, and rounded grains of quartz. The relations of the vivianite to these minerals clearly indicate its later formation, for the vivianite frequently incloses phosphate pebbles and

occasionally a small rounded quartz grain. More often the quartz grains are inclosed by the phosphate pebbles, whose surfaces are frequently pitted with cavities, suggesting the possible removal of some mineral. Some cavities in several of the pebbles examined were filled with vivianite. In no specimens of the vivianite examined were there indications of inclusions of the brownish-yellow ocherous material, but some of the vivianite crystals showed irregularities of surface similar to embayments which we believe resulted probably from external interference of the ocher on crystal growth.

ORIGIN OF THE VIVIANITE

The vivianite from the Florida locality is of secondary origin, formed we believe by the action of ferrous-iron solutions on the phosphate. Although rated at the present time as a rare mineral in the land pebble phosphate deposits, the conditions certainly appear to be favorable to a more general formation and distribution of the mineral in these deposits.

PETROLOGY.—*The significance of glass-making processes to the petrologist.* N. L. BOWEN, Geophysical Laboratory. (Communicated by A. L. Day.)

The entry of the United States into the war was the occasion of an enormously increased demand for optical glass to be used in all kinds of military instruments. The supply of glass from abroad was almost completely cut off. In the effort to meet the demand by domestic production many problems were met with for whose solution the advice and assistance of scientific men seemed desirable. Glasses are, for the most part, silicate mixtures that have been melted at a comparatively high temperature and then cooled to the glassy state. Since the principal activity of the Geophysical Laboratory has been the study of the behavior of silicates at high temperatures, it was expected that the experience of that organization might be of material assistance, and its services were therefore called upon. I was one of the several sent to the glass plant of the Bausch and Lomb

Optical Company, where we went hoping not merely to be of assistance in solving these urgent problems but expecting also to learn something of more general interest concerning the behavior of silicate liquids when handled on the comparatively large scale of the glass plant.

One of the principal requirements of optical glass is homogeneity. A fragment of glass to be used for a lens or prism must have the same refractive index and therefore the same chemical composition in all its parts, and from every pot of glass made a considerable proportion is rejected because it fails to fulfil this requirement. Naturally, the causes of inhomogeneity are diligently sought for, with the hope of removing them or reducing them to a minimum, and it may be stated that these causes are now pretty well understood. To those interested in the causes of inhomogeneity (differentiation) in masses of silicate rocks the factors that lead to inhomogeneity in these artificial silicate melts are perhaps of sufficient interest to merit description.

Optical glass is made in a great many varieties with a wide range of composition. SiO_2 and B_2O_3 are the principal acidic oxides, and the alkalies with CaO, PbO, BaO, and ZnO are the principal basic oxides, though a number of other oxides enter into the composition of special glasses. The alkalies, lime, and baryta usually go into the batch in the form of carbonates; lead and zinc as oxides; and silica as quartz sand. The carefully mixed batch is usually fed in several instalments into the pots, which have already been heated to the melting temperature. Factors tending to produce inhomogeneity immediately set to work. Some constituents of the batch are readily fusible, others, especially the sand, are quite refractory. The more fusible portions quickly form a liquid which tends to filter downward through the porous structure formed by the grains of the more refractory material. This action is especially marked in the heavy glasses rich in lead.

As typically developed the result may give every appearance of liquid immiscibility and the formation of two liquid layers. The two layers may be sharply marked off from each other and may so persist throughout the run. But that we have here no

true case of liquid immiscibility and that the persistence of two layers is due entirely to the slowness of diffusion is shown by the fact that appropriate stirring will completely eliminate this layering and give a single homogeneous liquid. When real immiscibility occurs in the glass pot, as it does under certain cirstances, it is quite a different matter. If the alkaline carbonates used in the batch contain a considerable amount of chloride or sulfate, these salts form a separate liquid layer which floats on top of the glass, forming the "salt water" of the glass-maker. No amount of stirring, however vigorous, will render such a mass homogeneous. This immiscibility between silicate, on the one hand, and sulfate or chloride, on the other, serves but to emphasize that immiscibility between silicate and silicate is not encountered in the whole range of glass compositions.

This process of settling down of heavy liquid through the porous mass of the batch can take place only at a stage when the mass is mostly solid. A factor tending to produce a closely related result comes into play at the stage when the mass is mostly liquid. Of all the ingredients of the batch the sand is usually the last material to dissolve. The sand grains tend to rise in the liquid and thus to render the upper parts more siliceous and of lower density. This action results in a continuous density gradient rather than in a sharp division into two layers. That it is not a spontaneous arrangement of the liquid according to the Gouy-Chaperon phenomenon is shown by the fact that as time goes on diffusion tends to lessen the gradient rather than to increase it.

Figure 1 is a photograph of a fragment of glass taken from such a pot, the straight edge being part of the original upper surface of the glass. Two parallel plane faces were cut normal to this surface and the specimen was photographed in a bright light close to a white screen. Under these conditions heavy shadows are cast by the globules of low refracting glass surrounding the silica grains and by the tails of similar material pointing downward from them. It is obvious that silica is continually being transferred towards the top.

There can be no doubt of the correctness of this explanation of the density gradient as a result of the floating of sand grains.

for fortunately the action can be interrupted and observed at an intermediate stage. When the pot is removed at such a stage and the glass is chilled, sand grains are found suspended in the glass. That they were rising slowly in the liquid and dissolving at the same time is shown by the fact that pointing downward from each grain there is a tail of glass of lower refractive index than the surrounding glass.

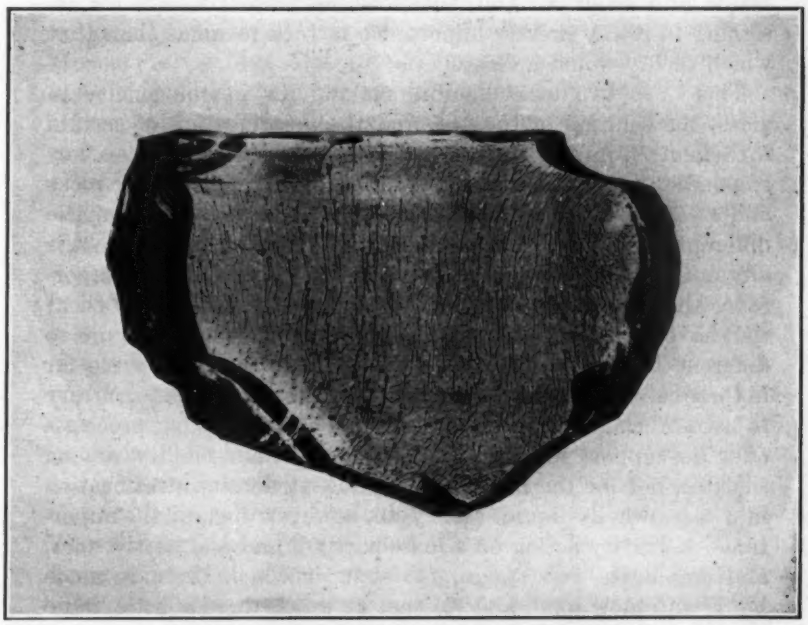

Fig. 1. Glass containing rising silica grains. Natural size.

In a former paper[1] I criticized the interpretation that has been offered of the result of a certain experiment by Morozewicz. The glass from his experiment showed a density and composition gradient, with the heavier portion at the bottom of the pot, and this arrangement had been explained as the result of the Gouy-Chaperon action. I offered the suggestion that the ar-

[1] *The later stages of the evolution of the igneous rocks.* Journ. Geol., Suppl. to Vol. 23, p. 5. 1915.

rangement was due to differential melting with the sinking of heavy liquid at an early stage and the rising of silica grains at a later stage, though I had not at that time seen or studied the phenomenon. A careful study of the behavior of the ingredients of a glass batch leaves no question as to the correctness of this interpretation. There is, then, no experimental basis for the belief in an appreciable result from the Gouy-Chaperon action in a small pot and, therefore, no present reason for assigning to it any greater importance in rock magmas than that which theory would indicate.

There are two other factors making for inhomogeneity in glass: the solution of the pot, and the volatilization of certain ingredients from the surface of the liquid. No doubt the corresponding processes, namely, solution of the surrounding rocks and escape of material into them, have their place in magmatic differentiation, but if their quantitative effect in the glass-pot is any criterion they cannot be regarded as approaching in importance the two processes (sinking of liquid and floating of silica) that have been described above. However, the conditions are so different that one should be careful not to push the analogy too far in these cases. It may be safely stated, however, that, contrary to certain claims that have been made, glass-making processes offer no support for the belief in liquid immiscibility among silicates, nor for the belief in a significant density stratification in a mass wholly liquid. They do, however, suggest the importance of gravity acting on a mass partly liquid and partly solid, and emphasize two stages, (1) that at which there is much liquid and little solid, and (2) that at which there is little liquid and much solid. The effects of these processes in magmas,—sinking of crystals at an early stage of crystallization and squeezing out of residual liquid at a late stage,—have been discussed in some detail elsewhere.[2]

The association of gabbro with granite or of basalt with rhyolite, and the complete absence of intermediate types that is often noted, have been held by some to necessitate some sort of discontinuous differentiation, whereas crystallization-differentiation should, for the most part, be continuous. Evans has offered the suggestion that in aqueous magmas there may be a

[2] Op. cit.

separation into two liquid portions, the lighter of which contains most of the water together with much silica, alumina, and the alkalies.[3] This is, of course, a possibility not altogether to be excluded, nevertheless all the available evidence is against it. Such experimental work as has been done hitherto on aqueous silicate melts gives no indication of a tendency towards a separation into two liquid layers.[4] But the range of this work is limited as yet and one must fall back largely upon examination of the geological evidence. Over against the lack of types intermediate between gabbro and granite (granophyre, micropegmatite) in some localities should be placed the abundance of intermediate types elsewhere. Again, if we examine the gabbro of a gabbro-granophyre occurrence we almost invariably find a certain amount of the granophyre occurring in the gabbro, frozen in as Daly puts it.[5] And when we examine the manner of occurrence of this frozen-in material we find nothing to lead us to believe that it represents an immiscible liquid. It does not form globular masses, large and small, scattered through the gabbro. It occupies crystallization interstices with all the marks of a crystallization residuum. Add to this the fact that it corresponds in composition with the kind of crystallization-residuum one is led to expect from experimental studies, and the reasons for appealing to liquid immiscibility may be regarded as of insignificant weight. Many petrologists regard liquid immiscibility as the ready solution of all difficulties. Realizing that present evidence is against it, some are led to "hope" that it may yet be experimentally demonstrated in silicate magmas. Until then one must regard its occurrence in silicate magmas as resting on pure assumption, an assumption that is in most cases not even helpful, and probably never preferable to the well-supported theory of crystallization-differentiation.[6]

[3] J. W. Evans. Discussion of paper by G. W. Tyrrell on *The picrite-teschenite sill of Lugar*. Quart. Journ. Geol. Soc. **72**: 130. 1917.

[4] G. W. Morey and C. N. Fenner. *The ternary system H_2O-K_2SiO_3-SiO_2*. Journ. Am. Chem. Soc. **39**: 1173. 1917.

[5] Igneous Rocks and Their Origin, p. 241.

[6] I would be the last, however, to claim complete miscibility between sulfides and silicates. Cf. Tolman and Rogers (*A study of the magmatic sulfid ores*. Stanford Univ. Publ. 1916, p. 10).

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this JOURNAL and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Strontianite deposits near Barstow, California.* ADOLPH KNOPF. U. S. Geological Survey Bulletin, 660–I. Pp. 14. 1918.

Strontianite in economically important quantity has recently been found near Barstow, San Bernardino County, California. The formation in which the deposits occur consists of a series of lake and terrestrial beds of Upper Miocene age. A threefold subdivision of the beds may easily be recognized. The strontium deposits are restricted to the middle subdivision, which is made up chiefly of grayish-green clay in thick beds. In places reefs of algal limestone are prominent, and obviously this part of the formation was laid down in a lake.

Strontianite and strontium-bearing rock have been found at a large number of places in a belt about 2 miles long. They occur as layers that lie parallel to the bedding of the inclosing clays and are distributed at intervals through a thickness of several hundred feet. The strontianite occurs in two forms—as fibrous masses of resinous color and luster and as dense, exceedingly fine grained gray or drab material, which in appearance exactly resembles limestone. The two varieties occur separately as a rule, but in some deposits they are intermingled, spherulites of coarse resinous strontianite being irregularly scattered through gray aphanitic strontianite rock. Some celestite is present in the lower-grade material of the district.

The thickest body of pure spherulitic strontianite that had been found at the time of visit is 14 inches thick, but the gray aphanitic strontianite rock had been found in layers as much as 3 feet thick.

The strontianite deposits were formed by the replacement of the lacustral limestone beds that are interstratified in the clays. They thus differ widely from the only other commercially productive strontianite deposits—those of the Münster district, Westphalia—which consist of a series of steeply inclined veins cutting horizontal marine

calcareous shales of Upper Cretaceous age. They resemble them in one fundamental respect, however, in that they were formed later than the strata that inclose them.

GEOLOGY.—*Geology and water resources of Big Smoky, Clayton, and Alkali Spring valleys, Nevada.* OSCAR E. MEINZER. U. S. Geological Survey Water-Supply Paper 423. Pp. 167, with maps and other illustrations. 1917.

This paper describes in detail three typical desert basins of the Basin-and-Range Province, with respect to their physiographic development and the absorption, circulation, and discharge of their ground waters.

Two cycles of erosion are shown in the Toyabe Range by two strongly contrasting types of topography. After the region had been eroded to a stage of maturity, probably late in the Tertiary period, it was faulted and uplifted, and the resulting escarpment was attacked by the streams, producing a very rugged front. Extensive faulting, continuing until recent time, is shown not only by precipitous mountain fronts but also by observed displacements, by polished surfaces, and by numerous escarpments in the valley fill. Evidences of glaciation, previously reported, are believed not to exist.

Elaborate systems of beach ridges or embankments, the largest nearly 50 feet high, mark the outlines of two Pleistocene lakes, designated by the author as Lake Toyabe and Lake Tonopah. Lake Toyabe, when at its highest level, was about 40 miles long, 9 miles in maximum width, and covered an area of approximately 225 square miles, or 18 per cent of the drainage basin in which it lay. Lake Tonopah, when at its highest level, was about 22 miles long, 5½ miles in maximum width, and approximately 85 square miles in area, or only about two-fifths the area of Lake Toyabe. This area was only 4.2 per cent of the total drainage basin tributary to the lake—a percentage less than one-fourth as great as that of Lake Toyabe.

The most important contribution of the report is a quantitative discussion of the origin, absorption, circulation, and discharge of the ground water, and of the criteria for determining areas of ground-water discharge. The amount of absorption was estimated chiefly by measuring stream flow at successive points on a part of the 54 small streams that discharge into Big Smoky Valley, and deducting for evaporation and transpiration from the wetted areas. The total annual supply of ground water was estimated to be several tens of thousands of acre-feet. The criteria for determining areas of discharge are (1) the mois-

ture of the soil and the position of the water table, (2) the appearance of soluble salts at the surface and the distribution of these salts in the soil, and (3) the distribution of plants of certain species that feed on ground water. On the map are shown the areas of discharge (aggregating 130,000 acres), and also the depths to the water table predicted on the basis of these areas.

Alkali Spring Valley illustrates the other type of desert basin in which there is no ground-water discharge, the facilities for underground leakage apparently being great enough to dispose of all the water that is absorbed.

Big Smoky Valley contains three distinct types of ground water, which are genetically related to the geologic formations from which they are derived. The processes of concentration were different in the lacustrine epoch than they are at the present time, and they differ in the clay cores below the playas from those in the surrounding zones of active discharge. O. E. M.

PALEONTOLOGY.—*Orbitoid foraminifera of the genus Orthophragmina from Georgia and Florida.* Papers by C. WYTHE COOKE and J. A. CUSHMAN. U. S. Geological Survey Professional Paper 108-G. Pp. 16, with 5 plates. 1917.

The first paper, by C. W. COOKE, describes several localities on Chipola River, Florida, Flint River, Georgia, and Suwannee River, Florida, at which species of *Orthophragmina* have been found in the Ocala limestone and enumerates the species of other organisms that are associated with them. The occurrence in the Ocala limestone of the genus *Orthophragmina*, which elsewhere appears to be restricted to the Eocene, is corroborative evidence of the Eocene age of that formation.

The second paper, by J. A. CUSHMAN, describes and figures 6 new species and one new variety of *Orthophragmina*. C. W. C.

ORNITHOLOGY.—*Second annual list of proposed changes in the A.O.U. check-list of North American birds.* HARRY C. OBERHOLSER. The Auk **34**: 198-205, April, 1917.

This is a résumé of recent ornithological activities not already treated in the American Ornithologists' Union Check-List of 1910, its supplement, and the First Annual List of Changes in the same. It consists of additions, subtractions, rejections, and the changes in generic, specific, and subspecific names made for zoological reasons, purely nomenclatural questions being excluded. In the present list there

are added 13 genera recently described or raised from subgenera; one species and 14 subspecies either described as new, revived, or recently captured within the boundaries of North America. Two species are eliminated as synonymous, and one proposed subspecies is rejected for the same reason. Furthermore there are many changes in names due to the recognition of additional genera, the descriptions as new of the North American representatives of wide-ranging species, the replacing of later by earlier names, and similar causes. This brings the subject down to December 31, 1916, and annual lists of the same character are to follow hereafter. H. C. O.

ORNITHOLOGY.—*A cooperative bird census at Washington, D. C.* HARRY C. OBERHOLSER. Wilson Bull. **39**: 18–29. March, 1917.

The importance of counting the actual numbers of birds over given areas, particularly during the breeding season, has already been shown. Similar censuses during the height of the spring migration are also of considerable value, both as a basis for comparison of the relative numbers of the different species in the same year and of the same species in different years. Such a count was made by 15 local ornithologists in the vicinity of Washington, D. C., on May 12, 1913. The country investigated consisted of the region within 20 miles of the city of Washington and comprised the valleys of the Potomac and Anacostia rivers, together with tributary streams and adjacent valleys. The routes of the 13 parties, each of which covered a distance of from 5 to 55 miles, traversed the country in all directions from Washington; and the results were very interesting. One fact of distribution was emphasized by these trips, which is that almost all the best places for birds about Washington lie in the more or less immediate valleys of the Potomac and Anacostia rivers. On this day the total number of species observed by all the parties was 129, of individuals actually counted, 1257. The largest number of species noted by any individual was 91, and the largest number of birds 3049. As the year 1913 was not particularly good for birds, this record is likely to be much increased by future observations. Three species, *Podilymbus podiceps*, *Totanus flavipes*, and *Dendroica palmarum hypochrysea*, noted on this day, had not previously been observed so late in the spring. The six most numerous species, in the order of their abundance, were, rather surprisingly, as follows: *Passer domesticus hostilis*, *Hirundo rustica erythrogastris*, *Iridiprocne bicolor*, *Melospiza melodia melodia*, *Chaetura pelagica*, and *Lucar carolinensis*. H. C. O.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

The Board of Managers, at its meeting on January 21, 1918, adopted the budget for the year 1918, increasing the allotments to the JOURNAL and the Committee on Meetings. The appointment of the following committees was announced:

Executive	*Membership*	*Meetings*
L. J. BRIGGS	PAUL BARTSCH	W. F. G. SWANN
R. B. SOSMAN	C. L. ALSBERG	C. S. HUDSON
WILLIAM BOWIE	G. W. COOK	K. F. KELLERMAN
G. K. BURGESS	W. J. HUMPHREYS	E. B. PHELPS
A. C. SPENCER	T. W. VAUGHAN	E. W. SHAW

Prof. FRIDTJOF NANSEN, of the University of Kristiania, Norway, now in Washington as Minister Plenipotentiary of Norway on special mission to the United States of America, has been elected an honorary member of the ACADEMY.

Messrs. O. H. TITTMANN and W. D. HUNTER were elected vice-presidents to represent the National Geographic Society and the Entomological Society of Washington, respectively.

ROBERT B. SOSMAN, *Corresponding Secretary.*

GEOLOGICAL SOCIETY OF WASHINGTON

The 320th meeting was held at the Cosmos Club, April 25, 1917.

INFORMAL COMMUNICATIONS

F. E. MATTHES read a greeting from Prof. Emmanuel de Margerie, former president of the Société Géographique de France, to the men of science in America, acclaiming with enthusiasm the entrance of the United States into the war.

REGULAR PROGRAM

G. P. MERRILL: *The rarer constituents of meteorites.*

G. F. LOUGHLIN: *The relation of copper and zinc in the carbonate ore at Ophir, Utah.* (Published in U. S. Geol. Survey Bull. 690-A.)

F. E. MATTHES: *The preglacial history of Yosemite Valley.*

The 321st meeting was held at the Cosmos Club, May 9, 1917.

INFORMAL COMMUNICATIONS

H. M. AMI: *Notes on the geology of Asia Minor.* The general geologic features were outlined with special reference to large undeveloped mineral resources.

REGULAR PROGRAM

WILLIS T. LEE: *Geology and scenery of the Rocky Mountain National Park.*

E. O. ULRICH: *The limitations of fossils in correlation.*

T. WAYLAND VAUGHAN: *Summary of results of study of marine bottom samples from Murray Island, Australia, the Bahamas, and Florida.*

The 322d meeting was held at the Cosmos Club, November 28, 1917.

INFORMAL COMMUNICATIONS

B. S. JOHNSON: *Chalmersite, $CuFe_2S_3$, a new ore of copper.* This mineral occurs extensively in greenstone in several localities in Alaska. It is associated with pyrrhotite and chalcopyrite. A satiny sheen due to cleavage is one of its distinguishing characteristics.

R. C. WELLS: *Tungstenite, disulphide of tungsten, a new mineral.* The disulphide of tungsten, WS_2, was found in material from the Emma mine, Little Cottonwood district, Utah, associated with pyrite, tetrahedrite, and galena. The mineral resembles graphite and shows slickensided surfaces but has a specific gravity of about 7.4. It is decomposed by aqua regia or by fusion with niter. It occurs massive, is dull to brilliant metallic in luster, is gray in color, and its hardness is about 2.5.

R. W. Stone: *The development of valuable magnesite deposits in the State of Washington.* This material is suitable for replacing imported magnesite for use in paper-making and for refractories. The significance of previously reported analyses of this material was not appreciated, and its rediscovery and recognition as a commercially valuable substance was purely accidental.

REGULAR PROGRAM

EUGENE WESLEY SHAW: *The "lakes" of northeastern Arkansas, and some features of the work of the Mississippi River.* Northeastern Arkansas has, according to all maps of the region, numerous large and small lakes. As a matter of fact most of these lakes are fictitious and many are not even swamps. The "lakes" are generally believed to have been caused by the New Madrid earthquake of 1811–12 and are widely known as "sunk lands." However, in most of them the surface has not been depressed; they do not have a basin form but instead are as high as surrounding country. All are in the heavily forested bottom lands of the lower Mississippi. In this forest there are natural openings that are swampy and some of them have shallow temporary or perma-

nent lakes. Such openings are found both inside and outside the areas mapped as lakes, and other features, such as low ridges and depressions and soil varieties, show little relation to the "lakes" or to their "shore lines."

The "lakes" were first reported and mapped by the original public land Survey of about seventy-five years ago. The field work, like much other public land surveying, was done under contract at a price perhaps too low for thorough and honest work. The early maps have been copied unquestioningly by all later ones, though strange to say there have been numerous later field examinations by various organizations, some purporting to be fairly detailed surveys of one sort or another, and few if any maps state that they are based on the land survey.

Ownership of the lands represented as lakes hangs on the correctness of the original survey. If it was correct and the lakes have become filled or drained their fertile beds must now be parceled out among those owning bordering lands—the riparian claimants. If, however, the old surveys were erroneous, the lands are now, it is said by lawyers, the property of the nation and open to homestead. Up to about 1910 no one claimed the lands—perhaps because they were poorly protected by levees and were more or less infested with malaria but perhaps to a large extent because of the reputation given Arkansas by songs and tales that have led homeseekers to pass over this rich State for less productive lands farther west. As a matter of fact few if any lands yield heavier crops of corn and cotton than those of northeast Arkansas, this area seeming to be too far north for serious difficulty with the boll weevil. In the past five years or since the question of title to the "lakes" was first raised, squatters have taken possession so far as allowed and there has been much contention between them and the riparian claimants.

The Department of Justice has brought suit to quiet the title to the lands in the government and since there is almost no one living who can testify as to whether or not the lands were lakes at the time of the old survey, the writer has been called upon at various times to determine if possible by the use of geology and physiography whether or not one or another of the areas was a lake at the time of the old survey. Ecologist H. C. Cowles was employed to gather for the same purpose the testimony of the trees of the immense hardwood forests that cover the "lakes" and surrounding land.

At first it seemed probable that the geologic and physiographic evidence would be indecisive because the whole region has been subject to annual overflow up to the time the levees were completed (and occasionally since) and hence to more or less erosion and sedimentation. It was found, however, that with the exception of the natural levee belts bordering the Mississippi and the larger bayous and other tributaries, erosion and sedimentation proceed very slowly and hence the presence or absence of basins, shore features, lake deposits, etc., could be used.

Although there are probably more low swampy areas inside the meander or "shore" lines of the lakes than outside and in places a bayou or other natural feature follows one of the lines for a part of its course, there is with one or two possible exceptions not only no recognizable lake basin, shore features, or lake deposits but for the most part no relation between the meander lines and any boundary of any feature or deposits, all manner of natural boundaries crossing the "shore lines" at all angles and all kinds of the natural features and deposits of the region being found both inside and outside of the "lakes."

The testimony of the trees, according to Dr. Cowles, has a similar bearing. The forest consists of oak, ash, elm, hickory, cottonwood, pecan, various gums, cypress, locust, maple, hackberry, sycamore, etc., large proportions of which are over seventy-five years old and none of which, according to the same authority, will germinate and grow in a lake—not even excepting cypress. The spur roots are with rare exceptions at the surface indicating no practically erosion or sedimentation.

Here and there are small tracts in which the timber was shaken down by the New Madrid earthquakes of 1811–12 and the surface being depressed, elevated, covered with the sand of "sand blows" or otherwise changed, a different society of trees has sprung up—all less than 105 years old and some growing astride, the still remaining fallen trunks. In such places events of the past century are clearly recorded.

Perhaps the most important inferences concerning the work of the Mississippi River are (1) that it is probably filling and not deepening this part at least of its valley and (2) that throughout most of the flood plain the rate of sedimentation is very slow—not more than a few inches per century.

E. S. BASTIN: *Genesis of the ores at Tonopah, Nevada.*

The 323d meeting was held at the Cosmos Club, December 19, 1917.

INFORMAL COMMUNICATIONS

LAWRENCE LAFORGE: *The occurrence of "Springs" in place names in the United States.* The word is more common in the Southern States. The relation of the place names to glaciation, limestone formations, habits of the people, etc., was referred to.

Discussion: DAVID WHITE called attention to the remedial qualities of springs and the disposition of the people of the South to resort to springs. T. W. VAUGHAN spoke of nameless springs throughout the Southern States and their association with limestone formations. O. E. MEINZER referred to the large springs along fault scarps in Nevada, and W. B. HEROY spoke of the ratio of area of a state to the number of place-names containing the word "Springs."

REGULAR PROGRAM

SIDNEY PAIGE: *Coal and iron in the terms of peace.*

H. E. MERWIN, *Secretary.*

PHILOSOPHICAL SOCIETY OF WASHINGTON

The 47th annual meeting (796th regular meeting) was held at the Cosmos Club, December 8, 1917; President BUCKINGHAM in the chair; 29 persons present. The minutes of the 46th annual meeting were read. The report of the Secretaries was read by Mr. Sweet. One member, Thomas W. Smillie, died during the year, one member resigned, and one member was dropped. Two members were transferred to the absent list, and two members were transferred from the absent to the active list. Twenty-four new members were elected. The present active membership is 170. Fifteen regular meetings were held, at which 37 formal and 7 informal communications were presented. A complete revision of the by-laws was adopted on November 24. According to the new by-laws the functions heretofore performed by the Executive Committee and the General Committee are concentrated in the General Committee. At the same time the General Committee is reduced to thirteen members.

The Treasurer's report through December 1, 1917, was read by Mr. MUELLER. The total receipts for the year, including cash balance of $443.66, were $2,537.29; the total disbursements were $2,353.16; cash balance on December 1, 1917, $184.13. The total par value of the investments now held by the society is $12,500. The report of the Auditing Committee, consisting of Messrs. MAUCHLY and BEARCE, was read by Mr. MAUCHLY. This committee reported that the statements in the Treasurer's report had been found correct. The reports of the Auditing Committees and the Treasurer were ordered accepted and placed on file.

The report of the Committee of Tellers, consisting of Messrs. SILSBEE and WHITE, was read by Mr. WHITE. A total of 43 ballots was received. From among those placed in nomination by the informal ballot, the following officers were duly elected for the ensuing year: *President*, G. K. BURGESS; *Vice Presidents*, W. J. HUMPHREYS, R. B. SOSMAN; *Corresponding Secretary*, E. C. CRITTENDEN; *Recording Secretary*, H. L. CURTIS; *Treasurer*, E. F. MUELLER; *General Committee*, J. A. FLEMING, W. F. G. SWANN (two year term) and R. L. FARIS, W. P. WHITE (one year term).

The rough minutes of the meeting were read and approved.

DONALD H. SWEET, *Secretary*.

The 797th meeting was held at the Cosmos Club, December 22, 1917; President BURGESS in the chair; 39 persons present. The minutes of the 795th meeting were read in abstract and approved.

The paper of Messrs. E. D. WILLIAMSON and L. H. ADAMS on *Measurement of the compressibilities of solids under hydrostatic pressure up to 12,000 megabars* was presented by Mr. E. D. WILLIAMSON. The paper was illustrated by lantern slides. Specimens on which measurements had been made were exhibited and some of the actual apparatus shown.

The compressibilities of the principal earth constituents are of

interest in a large number of geophysical problems but, owing to the difficulties that offer themselves in the experimental determination, practically no reliable data are available. This paper described a method by means of which the volume-change under hydrostatic pressure of any solid may be determined with an accuracy of about one part in a hundred million of the original volume of the solid. Results were presented for the metals gold, copper, silver, aluminum, zinc, tin, cadmium, lead, and bismuth; for the alloys brass, cast-iron, and tin-bismuth eutectic; the minerals halite, quartz, orthoclase, labradorite, oligoclase, pyrite, mica, and enstatite. The pressure range was from 2000 to 12,000 megabars (1 megabar = 0.987 atmosphere).

In carrying out the determination the solid, surrounded by a liquid such as kerosene, was enclosed in a thick-walled steel bomb fitted with a movable, leak-proof piston and pairs of simultaneous readings were taken of (1) the displacement of the piston and (2) the pressure.

The P-ΔV graphs were found to be nearly straight lines, but there exists a slight though distinct curvature such that the graphs are concave to the pressure axis. For the more compressible substances, the curvature is sufficient to allow of a rough estimate of the change of compressibility with pressure. This change amounts to as much as 10 per cent of the value at the initial pressure for the most compressible substances.

The average compressibility of the earth at the surface was calculated to be 1.63 parts per million per megabar.

Discussion: The paper was discussed by Messrs. SWANN, WHITE, and BURGESS.

A paper by Messrs. N. S. OSBORNE and M. S. VAN DUSEN upon *Latent and specific heats of ammonia* was presented by Mr. M. S. VAN DUSEN. The paper was illustrated by lantern slides.

Using a calorimeter of the aneroid type, specially designed for the peculiar conditions, the specific heat and latent heat of vaporization of ammonia have been determined throughout the temperature interval $-40°$ to $+$ 40°C. The apparatus used has been previously described in detail before the Society. It consists essentially of a cylindrical metal shell suspended within a thermally controlled metal jacket. The metal shell or calorimeter, containing the ammonia to be investigated, is provided with an electrical heating coil and a platinum resistance thermometer.

In the measurements of specific heat two independent methods were used, each of which avoids sources of error present in the other. In the first method, the heat added to a fixed amount confined in the calorimeter under saturation conditions and the resulting change in temperature are measured By using data for the specific volumes of the two phases and the latent heat of vaporization, the corrections for vapor are applied, giving the specific heat of the saturated liquid.

In the second method the calorimeter is kept full of liquid at a constant pressure. The heat added to the variable amount in the calorim-

eter and the resulting change in temperature are measured. A correction for the heat withdrawn in the expelled liquid is determined by special experiments. By the use of data for the heat of pressure variation of the liquid obtained from separate measurements, the corrections for pressure variation are applied, the result being a second determination of the specific heat of the saturated liquid.

The greatest difference between the mean results of both methods and the results of either method as represented by empirical equations is less than 1 part in 1000.

In the measurements of latent heat the jacket temperature was kept constant while a measured amount of ammonia was evaporated, slightly superheated, and withdrawn from the calorimeter. The approximate amount of heat required to effect this change was added electrically, the small balance being due to thermal leakage and change in temperature of the system, both of which were kept small and were measured. Analysis of the process occurring in the calorimeter during an experiment leads to a method of calculation whereby data from other sources than the direct observations enter only in the computation of correction terms, which can be made small by careful manipulation.

The result of each of the determinations agrees with the mean result as expressed by means of an empirical equation within 1 part in 1000.

Discussion: The paper was discussed by Messrs. WHITE, BURGESS, SOSMAN, and BICHOWSKI.

The 798th meeting was held at the Cosmos Club, January 5, 1918; Vice-President HUMPHREYS in the chair; 54 persons present. The minutes of the 797th meeting were read in abstract and approved.

Mr. O. S. ADAMS presented a paper on *Lambert's conformal conic projection*. The paper was illustrated by lantern slides.

Since the spheroidal surface of the earth is nondevelopable, it is impossible to make a perfect map of a section of any extent upon a plane surface. The best that can be done then is to choose an approximation that may preserve the features desired in the proposed map. A projection is called conformal or orthomorphic when any infinitesimal element of the map is exactly similar to the element that it represents. The Lambert conformal conic projection is admirably suited to the mapping of any region that has no great extent in latitude. The parallels become concentric circles and the meridians become radii of this system of circles. The projection is for this reason very easily constructed and thus fulfils one of the practical requirements for a projection. With this method of projection, a map could be constructed of the United States that would not be in error of scale in any part by more than 1.2 per cent. The fact that angles are preserved and that the error of scale is within the limits of scaling makes its use in France of great service at the present time. The projection is of interest historically because it was originated by Johann Heinrich Lambert in 1772, and afterwards fully discussed by Gauss. Since the projection is conformal, it is especially interesting to mathemati-

cians as an example of the application of the theory of functions of a complex variable. This simple example of the broad subject of conformal mapping of one surface upon another deserves careful consideration by all who wish to get a thorough grasp of the subject that is so important in the natural sciences as well as in pure mathematics. All honor is due the Alsatian Lambert for his perception of the important features of such a method of projection. However, even he did not dream of the importance that the conformal relationship was to assume both in pure and applied mathematics.

Discussion: The paper was discussed by Messrs. SOSMAN, HARRIS, LITTLEHALES, and JONES.

Mr. WILLIAM BOWIE presented a paper on *Primary triangulation and precise leveling as done by the United States Coast and Geodetic Survey.* The paper was illustrated by lantern slides and by three reels of moving pictures which showed the instruments used in the precise leveling and primary triangulation and the amount of work that has been done in the United States, and also the methods of carrying on the various operations.

There have been completed to date about 38,000 miles of precise leveling and 14,200 linear miles of primary triangulation and primary traverse. These operations give standard elevations and geographic positions throughout the country which are used by surveyors and engineers for the control of their operations, especially in the map making of the country. The work is of particular value in State and international boundary surveys.

Three reels of motion pictures were shown; one gave an excellent idea of the methods employed by an up to date precise leveling party. As now conducted, the precise level is mounted on a small motor velocipede which runs on the railroad track. The instrument is mounted on the car in the morning and it is not dismounted until the day's work is completed. It is not even removed when the car is lifted from the track to allow trains to pass. The recording of the rod readings is now done on a listing adding machine which is mounted on a second motor car.

Improvements recently made in the methods of organizing and conducting the precise level party made it possible to increase greatly the rapidity with which this work is done. The maximum progress made by a precise leveling party in any one month was 159.6 miles of completed line. Each mile of this was leveled over at least twice. The total number of single miles of leveling in that month was 324. As much as 20 miles of single line were leveled in one day of seven hours of actual observing.

The second reel showed the erection of the towers or signals which are used in triangulation in a wooded or flat country to elevate the instrument to sufficient height to make it possible to observe from one point to another. The length of lines of the triangulation varies from a minimum of about 4 miles to a maximum of something over 100 miles. The signal is a double structure, consisting of an inner tripod

on which the instrument rests and an outer four-legged structure called the scaffold which supports the observer and the lightkeeper. The two structures are entirely independent of each other and do not touch at any point. The reel showed the operation of erecting one of these towers from the time the building party arrived at the station until the structure was entirely completed. These towers are usually from 40 to 60 feet in height and are built of lumber purchased at the point most convenient to the field of operation. The legs of the structure are set well into the ground and are strongly anchored to prevent their being blown over by the wind.

The third reel showed the method of conducting the observing party. It showed the automobile trucks used in carrying the party and outfit from station to station and the various operations connected with the observing. It also showed the lightkeeper at work with his signal lamp or heliograph. Practically all of the observations of primary triangulation are now made on sunlight reflected from a mirror called a heliograph and on the signal lamps used at night. The modern signal lamp has a very high candlepower and the light can be sent over long lines and through atmosphere which would make observing impossible with the old style of lamp. The new electric lamp is one having contracted filament with dry cells furnishing the electric current. In the older type of lamp the fuel used was acetylene gas.

The primary triangulation is carried on much more rapidly today than ever before, but there has been no decrease in the accuracy of the observations. The accuracy of the triangulation is that expressed by an average closing error of about 1″. The probable error of any one direction in the triangulation is usually less than ½″. This accuracy is very great, as is shown by the fact that one foot at a distance of 40 miles from the observer subtends an angle of 1″. The accuracy in the results is obtained by repeating the angles a number of times and taking the mean. The errors are probably caused by atmospheric conditions.

H. L. Curtis, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Among the members of the ACADEMY who are now with the military forces of the United States are:

Lieutenant Colonel R. F. BACON, with the Chemical Service Section of the National Army, in France.

Brigadier General WM. H. BIXBY, U. S. A., retired, President of the Mississippi River Commission and Division Engineer, Western Division River and Harbor Improvements, at St. Louis, Mo.

Major W. R. BLAIR, with the Meteorological Service of the Signal Corps, in France.

Major EDWARD H. BOWIE, with the Meteorological Service of the Signal Corps, in France.

Major ALFRED H. BROOKS, Geologist on the staff of General Pershing, American Expeditionary Forces, in France.

Major General WILLIAM CROZIER, U. S. A., Chief of Ordnance.

Major L. A. FISCHER, Ordnance Officers' Reserve Corps, Bureau of Engineering.

Major General W. C. GORGAS, U. S. A., Surgeon General, Medical Corps.

Lieutenant Colonel HENRY S. GRAVES, with the Twentieth Engineers (Forestry) in France.

Captain CAREY V. HODGSON, Engineers' Reserve Corps, at Anniston, Alabama.

Major DOUGLAS W. JOHNSON, National Army.

First Lieutenant WALTER D. LAMBERT, Engineers' Reserve Corps.

First Lieutenant M. W. LYON, JR., Medical Reserve Corps, at Walter Reed General Hospital, Washington.

Colonel JOHN MILLIS, U. S. A., Corps of Engineers, at the Office of the Division Engineer, Southeast Division, Savannah, Georgia.

Brigadier General A. W. VOGDES, U. S. A., Retired, at San Diego, California.

Major W. H. WILMER, member Medical Research Board, and Assistant to Chief Surgeon, Aviation Section of the Signal Corps.

Captain FRED. E. WRIGHT, Ordnance Officers' Reserve Corps, detailed to the Bausch & Lomb optical glass plant in Rochester, New York.

Dr. H. M. AMI, formerly of the Geological Survey of Canada, is spending the winter in Washington. Dr. Ami is in charge of problems of war metals and minerals in the Trade Department of the British Embassy.

Dr. GEORGE E. HALE, Director of the Mount Wilson Solar Observatory at Pasadena, California, has been in Washington since last spring as Chairman of the National Research Council, which is now acting as the Department of Science and Research of the Council of National Defense.

Mr. NICHOLAS H. HECK has been transferred from the Coast and Geodetic Survey to the Navy Department, as a Lieutenant in the Naval Reserve Forces.

Dr. GEORGE TULLY VAUGHAN has been called to active service in the Medical Corps of the Navy.

Dr. OTTO KLOTZ, who with the late Dr. W. F. King, his predecessor, was a founder of the Dominion Astronomical Observatory at Ottawa, has been appointed Chief Astronomer and Director of the Observatory. Dr. Klotz has presented his scientific library of some 2000 volumes, a collection of a lifetime, to the Observatory.

Prof. CHARLES A. KOFOID, of the Department of Zoology, University of California, has been elected a corresponding member of the Société de Pathologie Exotique of Paris.

Prof. J. C. MERRIAM, of the University of California, has been in Washington for several months on business connected with the National Research Council.

Dr. CHARLES DOOLITTLE WALCOTT, Secretary of the Smithsonian Institution, has been elected a corresponding member of the Académie des Sciences of Paris in the section of geology, in place of Sir ARCHIBALD GEIKIE, who has been elected a foreign associate.

The following have become members of the ACADEMY since the beginning of the year: Prof. CHARLES AUGUST KRAUS, Clark University, Worcester, Massachusetts; Dr. PHILIP S. ROY, 1200 Massachusetts Avenue; Prof. JOHN WARREN SMITH, Weather Bureau; Dr. EDWIN FREDERICK WENDT, Interstate Commerce Commission.